AI impact and possible consequences for service design

Vlad C. Coroamă • Roegen Centre for Sustainability

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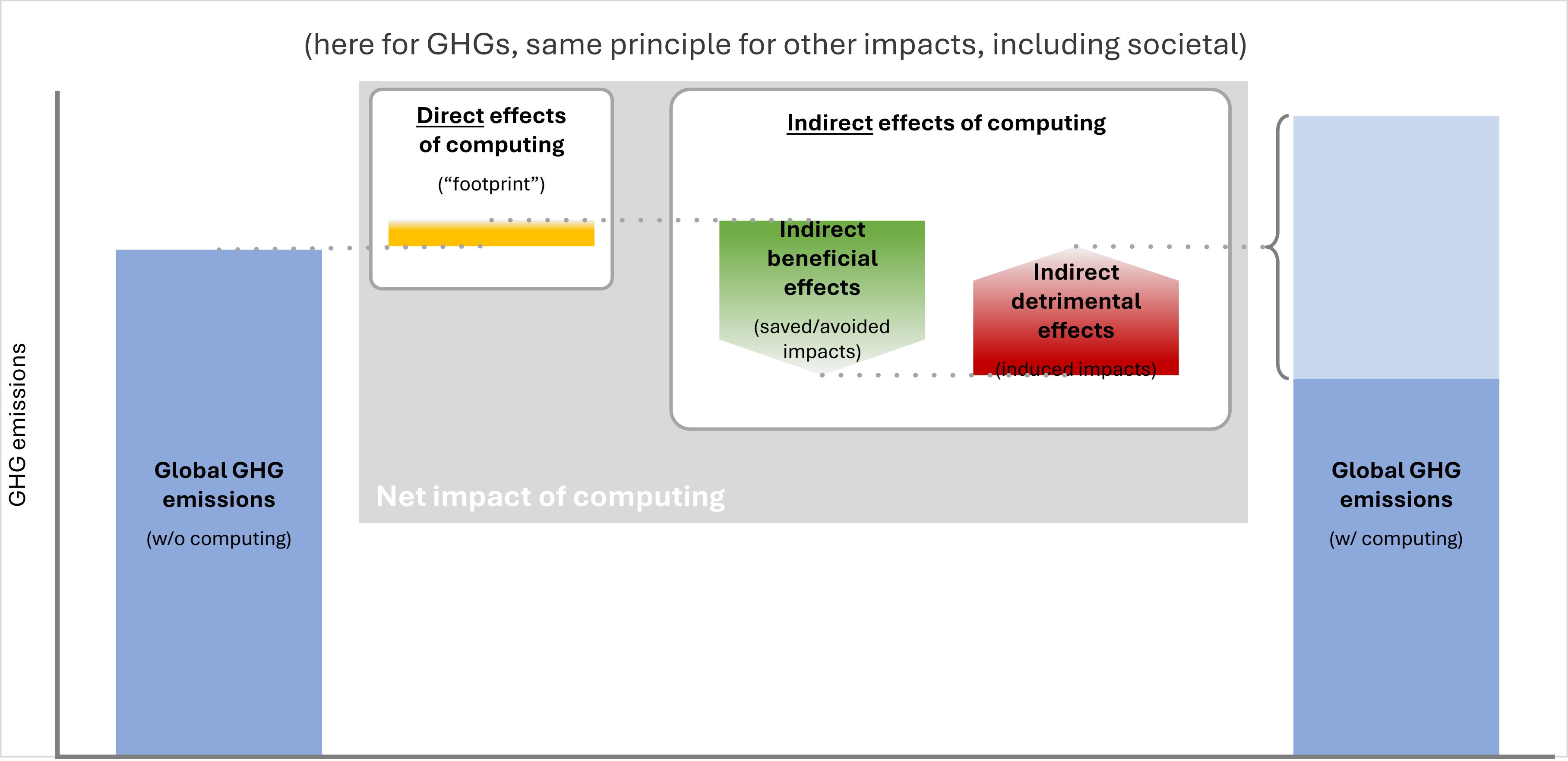
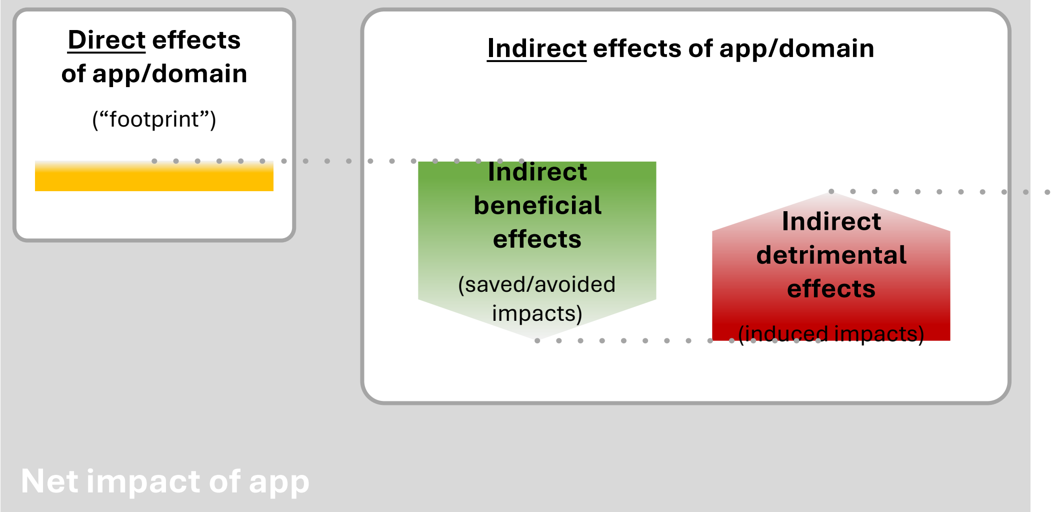
Assessing the Overall Impact of Computing

Computing and the Environment: It's complicated

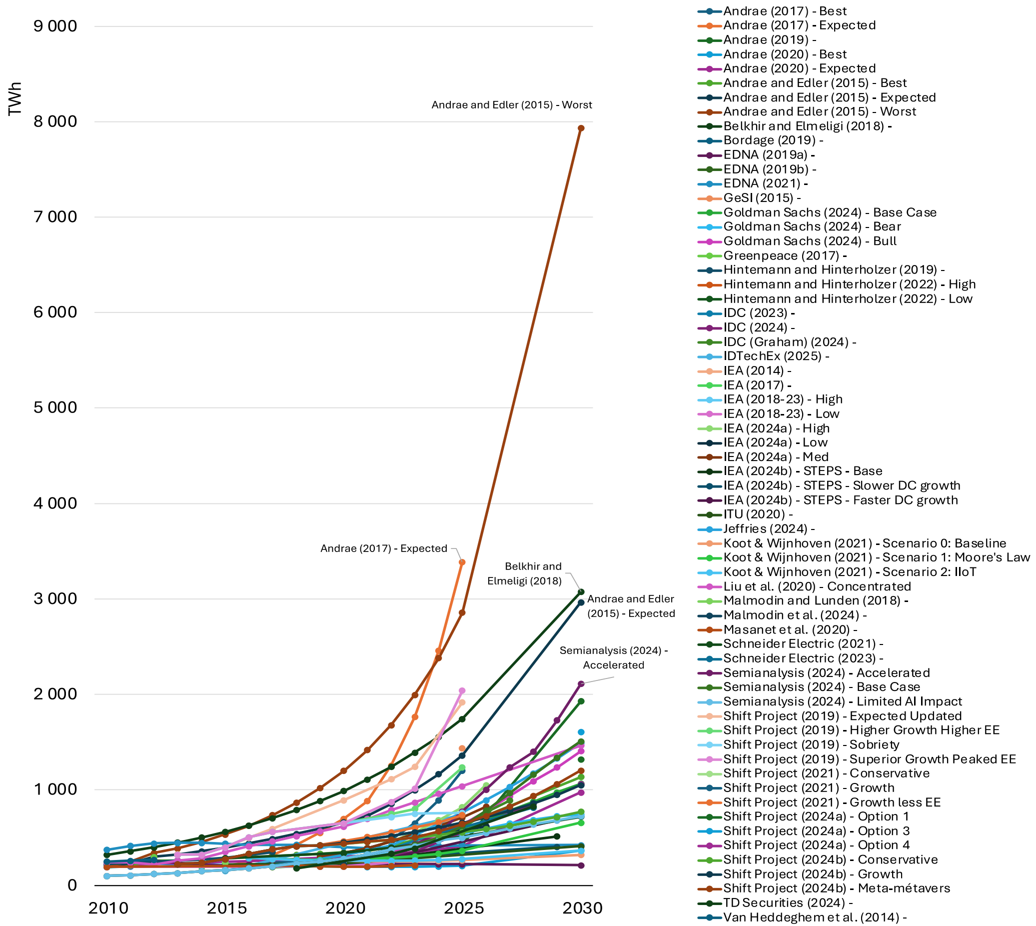


Adapted from Bremer et al. (2023): "Assessing Energy and Climate Effects of Digitalization: Methodological Challenges and Key Recommendations" – Framing paper of the RCN on Digital Economy and the Environment

Same principle for one app/service or domain (e.g., AI)

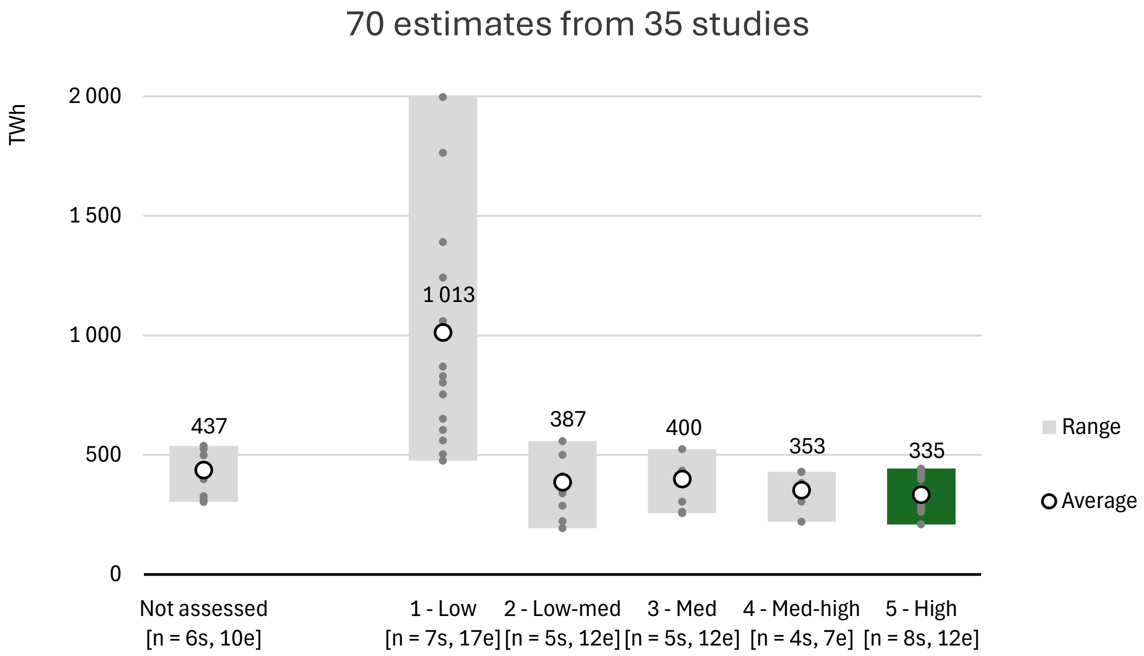


Global DC energy: Estimates since 2010 and projections to 2030



- 40-fold spread for 2030 projections
  - different methods and data sources
  - of different quality

Correlation between results and study quality

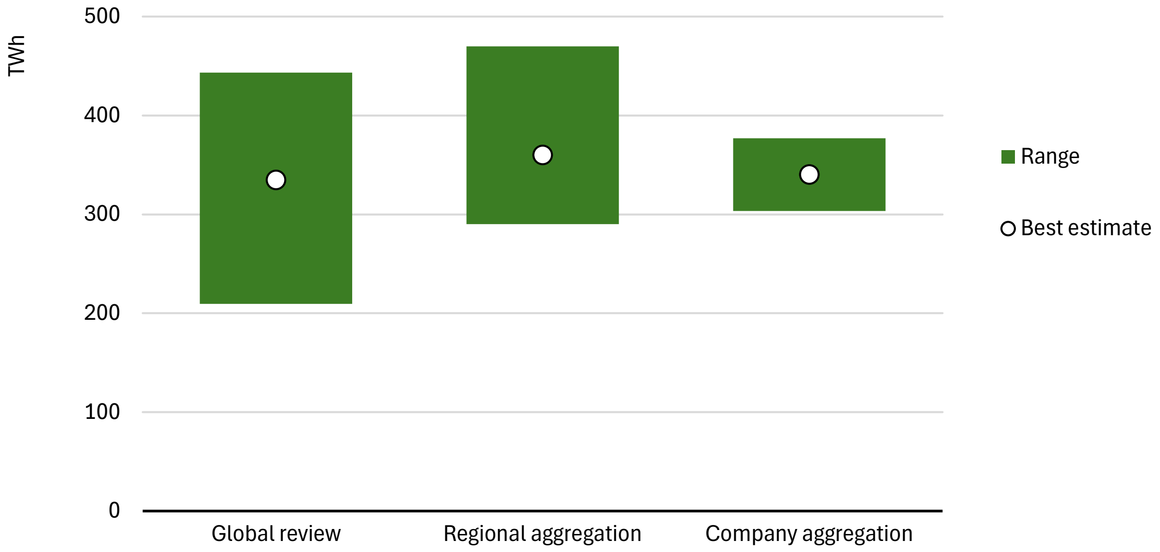


High-end estimates (with the biggest media coverage) correlate with low-quality studies

(Kamiya and Coroama 2025): "Data Centre Energy Use: Critical Review of Models and Results". – EDNA – IEA 4E TCP

Alternative assessments

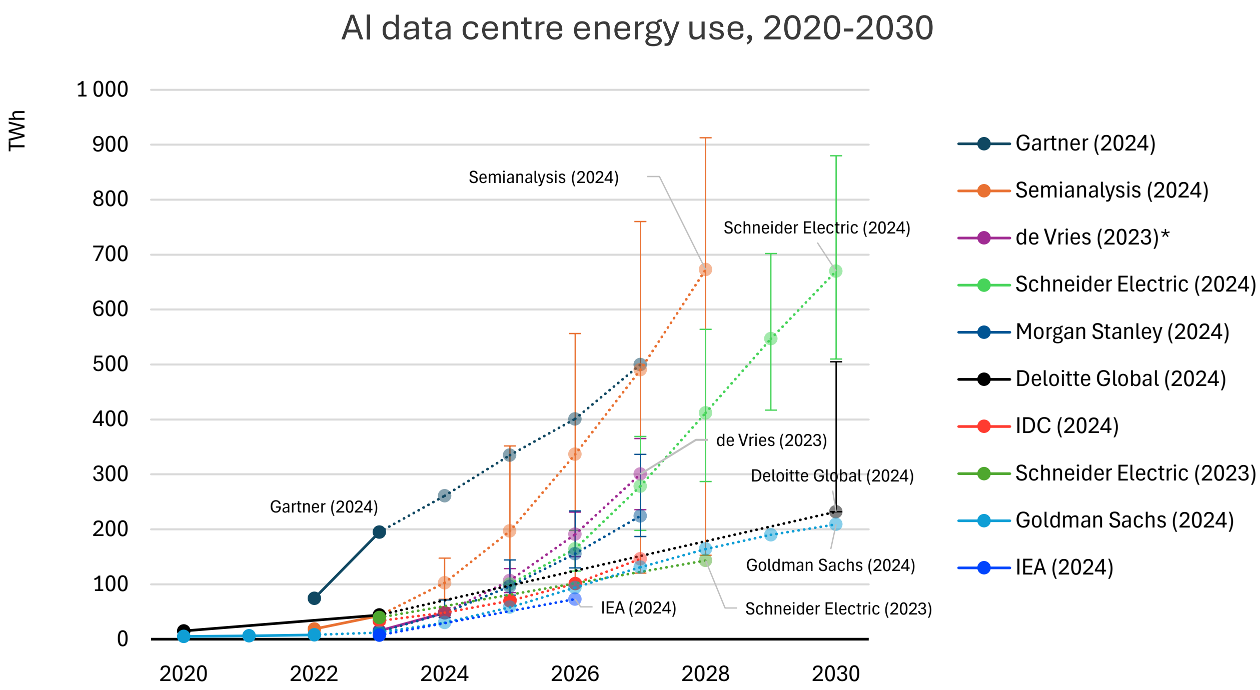
Aggregating regional studies and data from 60 of the largest DC operators



300 – 380 TWh / year seems the likely range for 2023

(Kamiya and Coroama 2025): “Data Centre Energy Use: Critical Review of Models and Results”. – EDNA – IEA 4E TCP

Selected global AI energy use projections



Sustained growth from a low basis, estimates for 2030: 200 – 900 TWh

(Kamiya and Coroama 2025): “Data Centre Energy Use: Critical Review of Models and Results”. – EDNA – IEA 4E TCP

Our best 2030 guess: ~300 TWh AI, DCs overall 700-900 TWh

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- How much do 100 TWh/year cost?
  - Nvidia Blackwell B100: TDP 700 W, 35k USD
  - Conservative assumptions
    - all run 24/7
    - 100% capacity
    - continuous power == TDP
  - Energy over 1 year:
    - 6.1 MWh for 35 k USD Capex
  - For 100 TWh
    - 16.4 m B100s required
    - 574 billion USD Capex
  - With conservative assumptions and ignoring
    - electricity costs, wages, building the DC, etc
- Reducing (a bit) conservative assumptions
  - Roughly 1 trillion USD per 100 TWh
  - Likely still conservative estimate
- 2-3 trillion global investment by 2030
  - seems more realistic than 7-9 trillion
- Not yet discussed
  - power production and transport
  - water consumption and scarcity
  - societal externalities
  - resistance and NIMBY
  - geopolitical issues and access to resources

Sanity check: Capex of ~ 1 trillion USD induce about 100 TWh yearly consumption

Indirect Effects and Possible Consequences for Ecodesign

Examples for environmentally beneficial and detrimental effects

Beneficial deployment of AI: Examples

- Efficiency through automatic control
  - data centres
  - building HVAC
  - industrial processes
  - smart farming & precision agriculture
- Modelling and forecast
  - production and consumption in smart grids
  - traffic flows
  - heating systems
  - weather and climate

Detrimental deployment of AI: Examples

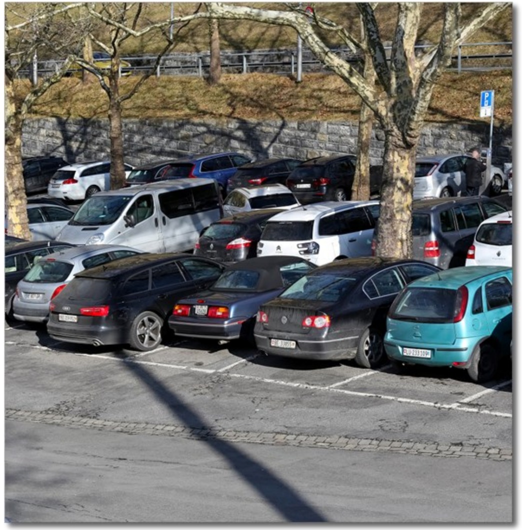
- E-commerce & fast fashion
  - increased consumption
    - lower transaction costs
    - reviews & price comparisons
    - time efficient
  - international deliveries
  - increased destruction of goods
- AI for oil & gas drilling
  - cheaper fossil fuels
- Autonomous vehicles
  - see following slides

Beneficial and detrimental consequences often intertwined; assessment extremely challenging

Why autonomous driving will induce more traffic

Why am I using public transportation today?

Working on my presentation on the way to the meeting



No parking available at the destination

Relaxing on the way back from the meeting

In a world of autonomous driving, all these reasons no longer exist → substitution of AVs for public transportation

(Coroamă and Pargman 2020) Skill rebound: On an unintended effect of digitalization, ICT4S 2020, Bristol, UK.

Methodological considerations: Bottom-up vs. top-down

- Bottom-up method
  - starts from individual application/service
  - identifies causal mechanisms and thus its possible (direct and indirect) effects
  - models each effect
  - aggregates them
- Pros
  - allows for precise assessments
  - evidences causal links → explanatory power
- Cons
  - can be resource-intensive
  - causal chains extremely complex and intertwined → effects will be missed
  - bias towards the obvious, not the important

- Top-down method
  - sets system boundary arbitrarily wide
  - identifies macro effects
  - e.g., EE-MRIO, QSD
- Pros
  - the only chance to account for "all" effects
  - may catch the subtle and hard to grasp
- Cons
  - causal links hard to establish
  - system boundaries still a challenge
  - inherently ex-post; ex-ante analyses only based on past experiences
  - resource-intensive (for different reasons)

Conclusions and possible consequences for ecodesign

Direct impact

- Globally, energy not worrisome
  - 1% of global electricity by 2030
  - slightly more than 0.1% of primary energy
- Power density is a problem
  - local power grids (Virginia, Ireland)
  - water consumption if scarcity
- Impacts of AI components' production
  - water and energy for microelectronics
- **Design services** against
  - GenAI usage (but for small dedicated models)
  - quick device obsolescence

Indirect impact

- Indirect effects usually more important than direct ones
  - both beneficial and detrimental
- Difficult to address
  - various mechanisms, some very subtle
  - large spatial and temporal scope
  - positive and negative deeply intertwined
- **Consider usage consequences at design**
  - e.g., Sustainability Assessment Framework (SAF) @ Vrije University Amsterdam
- **Educate for sustainability**
  - both students and practitioners

Thank you & let’s talk more

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